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SUGGESTIONS FOR PROSPECTING FOR EVAPORITE DEPOSITS IN SOUTHWESTERN VIRGINIA[1]

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Although salt and gypsum are plentiful in the United States, in the South Atlantic States these important minerals are known to occur only in southwestern Virginia, in deposits that crop out along the valley of the North Fork of the Holston River between Plasterco, in Washington County, and Locust Cove, about 20 miles to the northeast, in Smyth County (fig. 1). Salt has been produced commercially at Saltville, by brine methods, since the late 1700's. Gypsum was first mined about 1830 near Plasterco, and since then has been mined at many places between Plasterco and Locust Cove. One gypsum mine is now in operation at Plasterco, and a second is being opened at Locust Cove (Mineral Industries Journal, 1963). Because these deposits supply only a fraction of the salt and gypsum used in the South Atlantic States the discovery of additional sources of either mineral would be of benefit to the economy of the area. The purpose of this report is to describe briefly the geologic setting of the evaporites in Smyth and Washington Counties and to suggest other areas in southwestern Virginia where additional deposits might be found.

[1] Reprinted from U. S. Geological Survey Professional Paper 525-B, p. 29-33.

[2] U.S. Geological Survey, Washington, D. C.

GEOLOGIC SETTING OF THE EVAPORITE DEPOSITS

The evaporites in Virginia are found locally in the Maccrady Shale of Mississippian age, which consists chiefly of red and yellow mudstone, soft shale, and thin beds of sandstone and dolomite. The formation is generally between 50 and 100 feet thick, but undisturbed thicknesses of 800 feet have been reported (Butts, 1940, p. 354). Underlying the Maccrady is the Price Sandstone of Mississippian age, a resistant unit that consists of fine-grained yellow sandstone and beds of shale. Overlying the Maccrady is the Little Valley Limestone which is here reinstated to former usage. It is of Mississippian age and consists predominantly of argillaceous limestone, with some beds of sandstone and shale. Although exposures of the Maccrady in Virginia are generally poor, the formation can be traced in narrow bands, seldom more than a mile wide, northeastward for about 120 miles from the Virginia-Tennessee line, through Scott, Washington, Smyth, Wythe, and Pulaski Counties, to a point about 3 miles west of Blacksburg, in Montgomery County (fig. 1). Faults, which come to the surface south of the Maccrady Shale through much of this belt, have thrust older rocks over the Maccrady. Another outcrop belt of the Maccrady is in Lee, Wise, and Scott Counties,

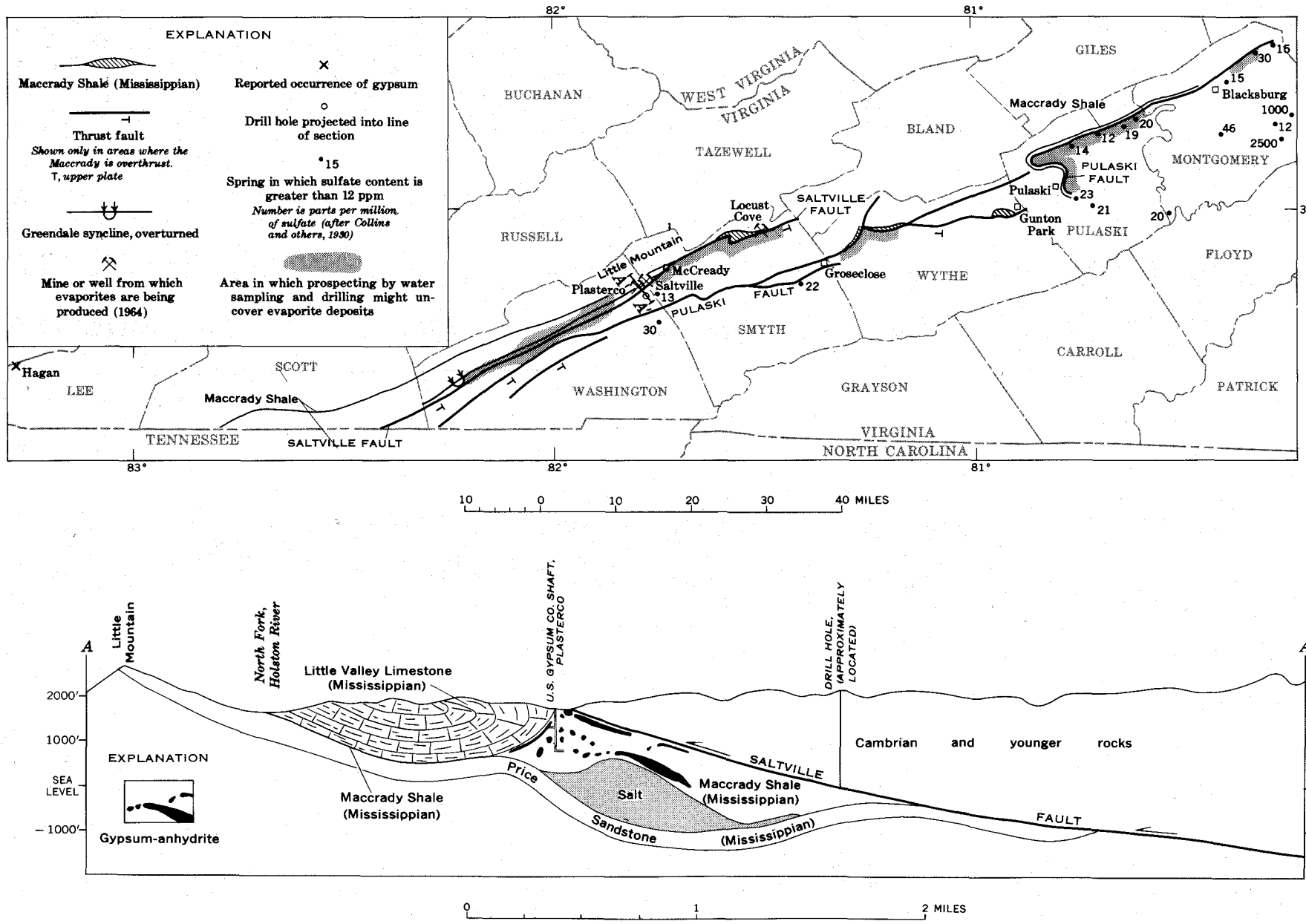

Figure 1. Map of southwestern Virginia, showing outcrop area of the evaporite-bearing Maccrady Shale of Mississippian age (after Calver, 1963). Schematic section A-A' shows relation of the Maccrady Shale to the Saltville fault (after Cullison, 1938; Nelson, 1958; topographic profile from Saltville and Glade Springs 7½′ topographic maps).

but because the Maccrady here is thin and more clastic than that at Saltville (Stose, 1923, p. 53), and because evaporites probably are not present, this outcrop is not included on figure 1.

An understanding of the effect of the Saltville thrust on the Little Valley Limestone and the Maccrady Shale, which can be demonstrated at Plasterco, may be helpful in finding additional evaporite deposits in Virginia. The Little Valley Limestone has been folded into an overturned northeast-trending syncline by the Saltville fault, which has thrust Cambrian rocks over Mississippian rocks. Northeast of Saltville, the Cambrian rocks rest directly on the Maccrady and make up the uplands on the southeast side of the valley of the North Fork of the Holston River. Little Mountain on the northwest side of the Valley is formed by the resistant Price Sandstone. The Saltville fault dips southeastward at angles that range from 20° to 60°. A hole drilled about a mile southeast of Plasterco passed through the fault into the Maccrady at a depth of 2,400 feet (Nelson, 1958). A sandstone which is presumably the Price Sandstone was cut below the Maccrady at Plasterco by a drill hole in the mine, according to Mr. H. D. Decker, of the U.S. Gypsum Co. (oral communication, 1957). These relations are shown on a schematic cross section through Plasterco (fig. 1).

At Plasterco the Maccrady was thickened to at least 2,000 feet, and consists of both bedded and jumbled, detached masses or blocks of gypsum, anhydrite, salt, sandstone, and limestone in a matrix of red and green mudstone and shale. The amount of salt increases with depth; below about 1,500 feet it makes up most of the Maccrady. Cooper (1964, p. 93-95) comments on the tremendous thickening of the Maccrady and other formations within the Greendale syncline northwest of the Saltville fault, and attributes this thickening at Saltville and Locust Cove to downfolding during deposition of the Mississippian rocks. At least part of the thickening of the Maccrady is evidently due to plastic flowage of salt and calcium-sulfate rocks, however, for both rocks are known to thicken considerably along the axes of folds.

Surface indications of the evaporites are sparse. Salt is found in salt springs and salt licks near Saltville, and gypsum in isolated outcrops in the Maccrady along the North Fork from Plasterco northeastward to Locust Cove. In the subsurface, bedded calcium sulfate occurs at the top of the Maccrady both under the Saltville fault on the southeast side of the valley and under the Little Valley Limestone on the northwest side of the valley (fig. 1). Within the upper part of the Maccrady the calcium sulfate, sandstone, limestone, and salt are in blocks typically 50 feet long, 20 feet high, and 15 feet wide. The blocks of gypsum, which are elongated northeastward parallel to the outcrops of the Maccrady, are randomly distributed through the clay matrix, and finding new blocks is difficult. The calcium sulfate is mainly gypsum down to a depth of about 1,000 feet; below that depth anhydrite predominates. The gypsum is white, is medium to fine grained, and is either massive or laminated with shale; the gypsum laminae are as much as 5 mm thick and the shale laminae as much as 1 mm. The laminae are original bedding features within the gypsum. Masses of petroliferous shale and black magnesian limestone occur at places within the gypsum.

ORIGIN OF THE EVAPORITES

The origin of the evaporites in southwestern Virginia has been the subject of much speculation. Several early writers regarded the gypsum as an alteration product of limestone, possibly of very recent age (Rogers, 1884, p. 141-142, reprinted from a report of 1836; Lesley, 1862; and Stevenson, 1885). Eckel (1903, p. 406) concluded that both the salt and gypsum were formed as part of the original depositional sequence through the evaporation of sea water, and he gave an early Carboniferous age to the deposits. Stose (1913) described the evaporite-bearing beds and named them the Maccrady Shale from exposures near Maccrady (McCready on fig. 1), a town northeast of Saltville. He believed that the evaporites were derived from calcareous-argillaceous sediments that originally contained finely disseminated gypsum and salt which had been precipitated in a partly enclosed arm of the sea during the deposition of the Maccrady Shale, and that the evaporites were later further enriched as ground waters dissolved calcium carbonate and carried it away. Since Stose published his report in 1913, the evaporites have been better exposed and better explored. Because laminated gypsum, typical of bedded gypsum deposits, has been found in the isolated gypsum blocks, it is now certain that the salt

and calcium sulfate, probably in the form of anhydrite, were deposited as part of the original depositional sequence.

On the basis of stratigraphic conditions elsewhere it can be assumed that near Plasterco and Saltville the Maccrady originally consisted of bedded calcium sulfate, salt, shale, and thin sandstone in a unit that was about 100 feet thick. The Maccrady acted as a lubricated mass over which the thrust plate glided. In the process of thrusting, the overriding mass squeezed the Maccrady before it, concentrating the calcium sulfate and salt by plastic flowage, and thickening the formation. At this time, limestone and other impurities were included in the evaporites. Then, as Cullison (1938, p. 36) has suggested, the thrust distorted the rocks and broke them to form the isolated blocks. Fragments of the Little Valley Limestone and probably of the underlying Price were also broken off and included in the jumbled mass of the Maccrady. The bedded gypsum found in the Plasterco mine at the top of the Maccrady was little disturbed by the overriding mass; evidently most of the action of the thrust took place east and southeast of Plasterco.

AREAS AND METHODS OF PROSPECTING

Only in the 20-mile-long belt that extends northeastward from Plasterco is it certain that evaporites exist. Rogers (1884, p. 141) stated that gypsum extends northward from Plasterco along the North Fork of the Holston River into the Walker Creek valley, a distance of 40 miles, but there is no record that exposures of gypsum or salt have been found beyond Locust Cove. The basin in which the evaporites were deposited probably covered much more of southwestern Virginia than is now known to contain evaporites, but because of the soluble nature of both gypsum and salt very little evidence of their existence would be found on the surface. An 8-foot bed of gypsum in the Newman Limestone of Mississippian age, exposed in a railroad tunnel between Harlan County, Ky., and Hagan, Lee County, Va. (fig. 1), about 75 miles due west of Saltville (R. L. Miller, oral communication, 1964), encourages the belief that evaporites may be found elsewhere in southwestern Virginia. This occurrence is a few hundred feet stratigraphically above the Maccrady.

Study of the analyses of water from more than 225 springs in southwestern Virginia (Collins and others, 1930) suggests that gypsum is more widespread than is now known. On the basis of concentration of sulfate the analyses can be classified in two groups; in one the samples contain less than 8 parts per million of sulfate, and in the other they contain 12 ppm or more. Nearly 75 percent of the analyses show less than 8 ppm of sulfate, and 20 percent of them contain 12 ppm or more. These springs, which are mostly in Wythe, Pulaski, and Montgomery Counties, flow from the Cambrian rocks that have been thrust over the Maccrady Shale by the Pulaski or Saltville faults. Few of the analyses above 12 ppm of sulfate are from springs north of the Saltville fault. The locations of the springs yielding water that contained more than 12 ppm of sulfate are shown on figure 1. Among the 17 sulfate values shown, 15 range from 12 to 46 ppm, one is 1,000 ppm, and one is 2,500 ppm. It is not certain, of course, that the anomalous sulfate in the analyses comes from the solution of calcium sulfate, nor are there corresponding increases of sodium and chloride in the analyses. The fact that most of the springs with the higher concentrations of sulfate flow from the Cambrian rocks that have overridden the Maccrady strongly suggests that the sulfate in the ground water is derived from gypsum in the Maccrady. The absence of anomalous amounts of chloride in the analyses is not surprising, because any salt exposed to ground water would have long since been removed. The very high concentrations of sulfate are thought to reflect a relatively short distance of travel of the solution; the lower values probably are due to longer travel and greater dilution by ground water.

Even where all traces of evaporites have been removed from the outcrop, and where only a poorly defined collapse-breccia remains, deposits might still be found in the subsurface. Figure 1, which is from the geologic map of Virginia (Calver, 1963), shows where the Maccrady has been overridden by older rocks along the Saltville fault, which is in Smyth and Washington Counties, or along the Pulaski fault, the trace of which runs northeastward from Washington County to Montgomery County. Analyses of water from springs near faults should be examined for above-average concentrations of calcium sulfate. To be significant these concentra-

tions need not be especially high, for both the salt and gypsum are encased in clay which, where it is particularly impermeable, must protect these relatively soluble minerals from attack by ground water. Drilling should be done southeast of the outcrop of the Maccrady, and even southeast of the trace of the faults, because the thickest part of the Maccrady is downdip from the undisturbed outcrop along the North Fork of the Holston River (fig. 1). Care should be taken not to drill too far southeast of the trace of the fault, however, for the action of the thrust probably squeezed all the salt before it, so that within a mile or so southeast of the trace, all that remains of the Maccrady is likely to be a jumbled mass of clay, sandstone, and limestone.

The areas shown on figure 1, in which prospecting might be successful, include: (1) Smyth and Washington Counties south of the outcrop of the Maccrady and south of the Saltville fault; (2) Smyth and Wythe Counties south of the Pulaski fault, from Groseclose in Smyth County to Gunton Park in Wythe County; (3) an area from Pulaski northward and thence eastward into Montgomery County where the Maccrady is overthrust by the Pulaski fault; and (4) an area northeast of Blacksburg, in Montgomery County, in which the Maccrady does not crop out, but where spring water south of the Pulaski fault contains as much as 30 ppm of sulfate.

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Anhydrite in the Rome Formation

A recent examination of cuttings from the United Producing Company, Inc., No. 1-1532 J. M. Hoge well near Burkes Garden, Tazewell County, has revealed the presence of anhydrite in the Rome Formation. White, gray, and pinkish, finely crystalline to dense anhydrite occurs in the sample intervals 4833′-4852′, 4964′-5001′, 5077′-5118′ (well depths). Top of the Rome Formation is at 4026′.

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LARGE-SCALE SHELL PRODUCTION FROM HAMPTON ROADS

R. F. Pharr

On May 6, 1963, Radcliff Materials, Inc., a subsidiary of Southern Industries Corporation, Mobile, Alabama, began dredging buried shells (primarily oyster shells) off the Craney Island disposal area in Hampton Roads. The company's dredging operations have provided a new and large source of shell material for use in cement and lime manufacture, feed supplement, road construction, foundations for planting new oyster beds, and other uses. Although the use of shells for these purposes is not new in Virginia, their availability to the market in large quantities resulted from the advent of production by Radcliff Materials, Inc.

Permission to dredge the buried shell deposits was granted Radcliff Materials, Inc., by the Virginia Commission of Fisheries which first determined that no live oyster beds were present

in the area. A dredging royalty that is paid by Radcliff to the Commission is used to supplement the State's oyster planting and replenishment program. It was also necessary for the company to obtain a permit for navigation from the U. S. Army, Corps of Engineers.

The deposits which are being dredged off the Craney Island disposal area are composed almost entirely of oyster shells. The unconsolidated shell deposits range in thickness from 12 to 13 feet and are overlain by approximately 2 feet of silt and mud. The average water depth in the area in which dredging is done is 9 feet.

The company's dredge "Flamingo" (Figure 2) is designed specifically to dredge, wash, process, and load shells into barges. The dredge is 100 feet long, 38 feet wide, weighs 308 tons, has a working draft of 4 feet 10 inches, and can recover about 3000 cubic yards of shells per day. The dredge is equipped with a 42-inch cutter head that liberates the shells that are then passed through a 12-inch Amsco centrifugal pump. The shells are discharged from the dredge pump upline to a rotary-screen washer and from the washer down a chute to a barge tied alongside. Most deliveries of the shells are made by pulling a loaded barge by tugboat directly to the purchaser. Radcliff Materials, Inc., contracts with a number of local tugboat operators to transport their barges. A large stockpile is maintained,

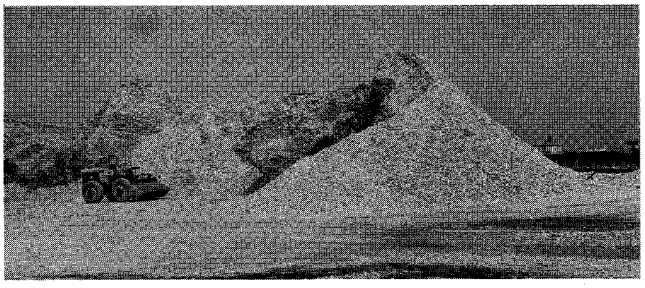

Figure 3. Stockpile of shells at Radcliff Materials, Inc., Foot of Pearl Street, Chesapeake.

however, on the yard adjacent to the company's office at the Foot of Pearl Street, Chesapeake (Figure 3). In order to move the "Flamingo" forward into an undredged portion of the shell bed, one of two spuds that anchor the dredge is raised, the vessel is then pivoted and the raised spud is lowered, thus walking the dredge forward. The dredge has a maximum swing of 260 feet, and a maximum cutting depth of 40 feet.

During the summer months the Commission of Fisheries is the largest purchaser of shells from Radcliff Materials, Inc. Foundations of shell material upon which new oyster beds are planted have been laid in many of the major rivers that enter the Chesapeake Bay. During the months of September, October, November, and December, a major part of the dredged shells is supplied to the Oyster Shell Corporation, Baltimore, Mary-

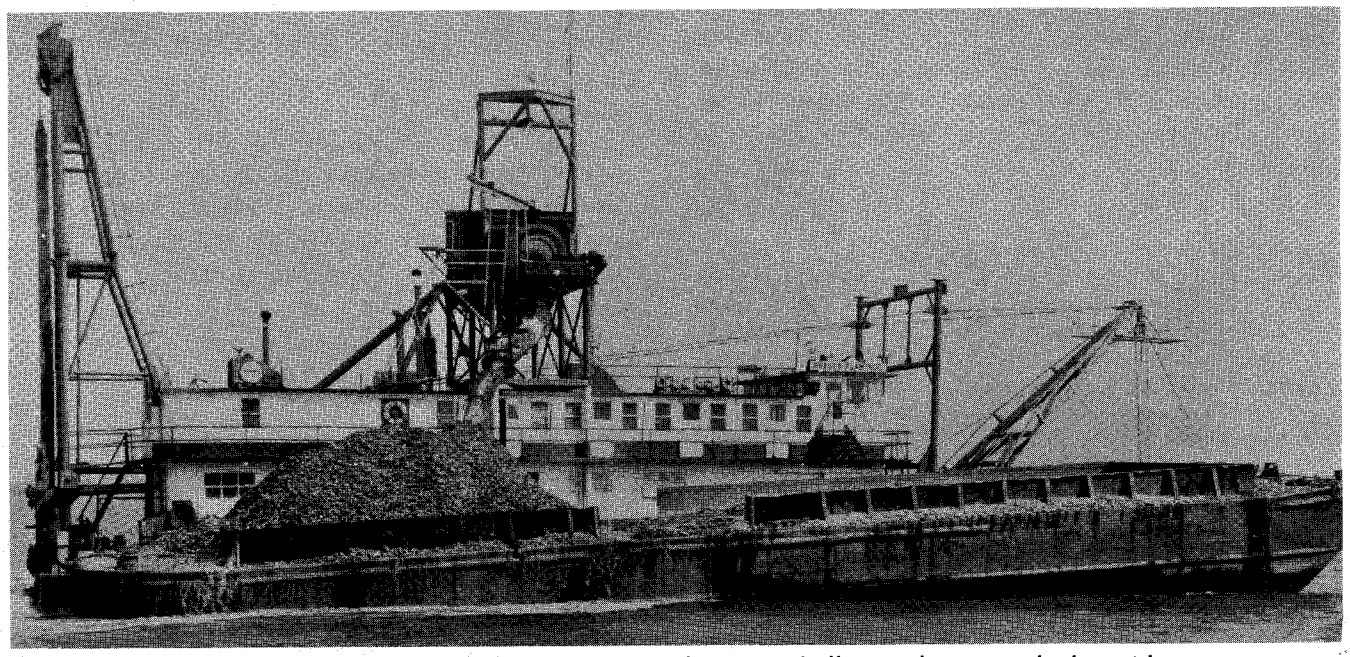

Figure 2. Radcliff Materials, Inc. dredge "Flamingo" discharging shells into barge tied alongside.

land, a subsidiary of Southern Industries, which utilizes the material in the manufacture of chicken feed. The Lone Star Cement Company, Chesapeake, purchases shells from Radcliff Materials, Inc., to supplement the calcareous marl which they produce at Chuckatuck, Nansemond County, for use in the manufacture of portland cement. The shells are also utilized locally in the manufacture of lime and in the construction of secondary roads.

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News Notes

W. E. Graham and Sons, Division of Vulcan Materials Company, is operating quarries in limestone and dolomite near Mt. Crawford and near New Market, Rockingham County, for the production of crushed stone. Portable plants are being utilized at both quarry sites. The company ceased quarrying operations near Genito, Powhatan County, in September 1965. The portable plant at this site will be installed at a new quarry site near Spottswood, Augusta County. The company operates other quarries in Fairfax, Goochland, Halifax, Mecklenburg, Pittsylvania, and Prince William counties.

Lambert Brothers Division of Vulcan Materials Company began production during March 1965 of crushed quartzite at a quarry located near Natural Bridge Station, Rockbridge County. The quartzite is shipped by rail to the Union Carbide Corporation, Alloy, West Virginia, for use as metallurgical flux. The company operates other quarries in Alleghany, Montgomery, and Washington counties.

The Ararat Rock Products Company of Mount Airy, North Carolina, has opened a new quarry in limestone near Callaghan, Alleghany County. A portable plant is being used to produce crushed stone for construction of a portion of Interstate Highway 64.

The Culpeper Stone Company commenced production during July 1965 of crushed granite at a quarry located near Flint Hill, Rappahannock County. The company operates other quarries for the production of crushed stone in Culpeper and Spotsylvania counties and a sand and gravel pit in Stafford County.

Southern Materials Company, Inc., began production of crushed granite on September 14, 1965, at a new quarry near Chester, Chesterfield County. The company also operates quarries in granite near Rawlings, Brunswick County; Petersburg, Dinwiddie County; and Bracey, Mecklenburg County, and several sand and gravel plants.

Sadler Materials Corporation is producing sand and gravel from pits at Curles Neck near Varina, Henrico County. The material is barged down the James River to the company's plant located at Little Creek, Virginia Beach, where it is processed primarily for use as road and concrete aggregate and masonry sand.

The Valley Sand Company, a new corporation, began production during September 1965 of sand and gravel for use in asphalt, concrete, and mortar, at a location along South River near Waynesboro, Augusta County.

The Clinchfield Sand and Feldspar Corporation has begun production of vein quartz in Bedford County and has installed a new plant at Lowry to process the quartz for exposed-aggregate purposes. The company also operates feldspar mines in the county and a feldspar-processing plant at Bedford.

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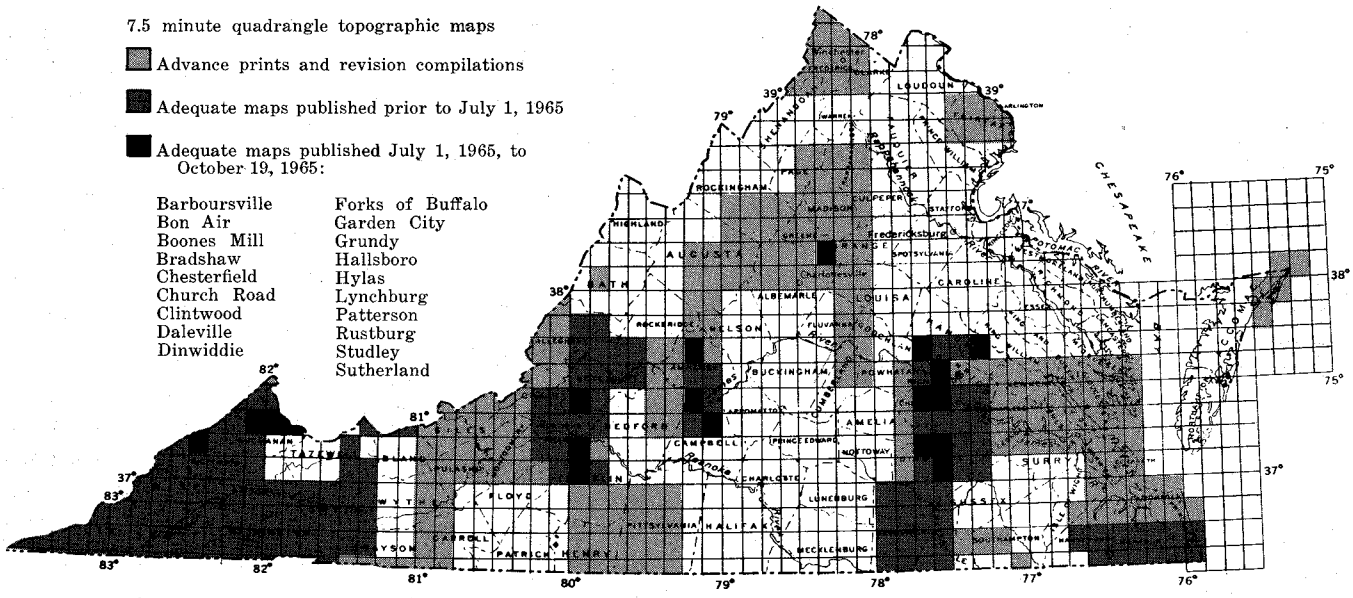

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